



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Mechanical Engineering, Automobile Engineering

Subject Code: BE05000291

Subject Name: Heat Transfer

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Nil
Rationale:	The course is prepared to provide the detailed understating of various modes of heat transfer and its applications in Mechanical Engineering. The course also provides the basic technical knowledge related to heat exchangers.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	To classify the heat transfer problems and to apply the principles of steady state one-dimensional heat transfer, extended surface and unsteady state conduction for commonly encountered Mechanical engineering problems.	32
CO-2	To identify the type of convection problems and to apply concepts of natural and forced convection for related problems	22
CO-3	To explain various laws of radiation heat transfer and to determine the radiation heat transfer between black and grey surfaces of simple Mechanical systems	22
CO-4	To practice LMTD and effectiveness-NTU method for simple heat exchange device	14
CO-5	To identify types of boiling and condensation heat transfer process and to use the same to estimate heat transfer coefficient for simple cases	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Mark s
L	T	P	PBL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/C A (I)	PBL (I)	ESE (V)	
45	00	30	45	120	04	70	30	20	30	50	200

* *Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.*



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Content:

Sr. No.	Content	Total Hrs
1	<p>Conduction: Fourier's law, effect of temperature on thermal conductivity of different solids, liquids and gases, generalized equation in Cartesian, cylindrical and spherical coordinates and its reduction to specific cases, One-dimensional steady state conduction, heat conduction through plane and composite walls, cylinders and spheres, electrical analogy, critical radius of insulation for cylinder and sphere, overall heat transfer coefficient</p> <p>Heat transfer from extended surface: Types of fin, heat flow through uniform cross-sectional area fin for various cases like infinitely long fin, fin insulated at the tip and fin losing heat at the tip, efficiency and effectiveness of fin, Estimation of error in temperature measurement in a thermometer well</p> <p>Transient heat conduction: lumped capacitance method for bodies of infinite thermal conductivity, time constant</p>	15
2	<p>Convection: Newton's law of cooling, dimensional analysis applied to forced and free convection, dimensionless numbers and their physical significance, empirical correlations for free and forced convection, Continuity, momentum and energy equations, thermal and hydrodynamic boundary layer, Blasius solution for laminar boundary layer, General solution for Von-Karman integral momentum and energy equations</p>	10
3	<p>Radiation: Absorptivity, reflectivity and transmissivity, black, white and grey body, emissive power, emissivity, Kirchhoff's law, Planck's law, Rayleigh-Jeans' law, Wien's law, Wien's displacement law, Stefan-Boltzmann law, intensity of radiation, radiation heat exchange between black bodies, shape factor, electrical analogy, radiation heat exchange between gray bodies, radiosity, irradiation, radiation shields</p>	10
4	<p>Heat exchanger: Classification, heat exchanger analysis, LMTD for parallel and counter flow exchanger, condenser and evaporator, overall heat transfer coefficient, fouling factor, correction factors for multi pass arrangement, effectiveness-NTU method for parallel and counter flow heat exchanger, introduction of heat pipe and compact heat exchanger</p>	6
5	<p>Two-phase heat transfer: Boiling of liquids, Pool boiling curve, modes of pool boiling, correlations for pool boiling, condensation of vapor, film wise and drop wise condensation, condensation on flat surfaces and horizontal tubes</p>	4
Total		45

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	60	10	00	00

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.



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The syllabus of Heat transfer directly contributes to:

SDG 7	Affordable and Clean Energy
SDG 12	Responsible Consumption and Production
SDG 13	Climate Action

Reference Books:

1. Heat and Mass Transfer by P.K. Nag, McGraw Hill
2. Heat and Mass Transfer: Fundamentals and Application by Yunus Cengel, McGraw Hill
3. Fundamental of Heat and Mass Transfer by Incropera and Dewitt, Wiley Publication
4. Principles of Heat Transfer by Frank Krieth, Raj M, Manglik, Mark S. Bohn, Cengage Learning
5. Heat Transfer by J P Holman , McGraw Hill

List of Experiments: (at least ten experiments from the following list should be performed)

1. To determine the thermal conductivity of given metal rod
2. To determine the thermal conductivity of the given composite walls.
3. To determine fin performance under forced convection.
4. To determine fin performance under natural convection.
5. To determine critical radius of insulation.
6. To determine heat transfer coefficient for transient heat transfer process.
7. To determine heat transfer coefficient by forced convection.
8. To determine heat transfer coefficient by natural convection.
9. To determine Stephan Boltzmann constant experimentally.
10. To determine the emissivity of gray body.
11. To determine overall heat transfer coefficient for hair pin heat exchanger.
12. To determine overall heat transfer coefficient for finned heat exchanger.
13. To determine the overall heat transfer coefficient of shell and tube type heat exchangers.
14. To study film and drop wise condensation and to determine the film co-efficient.

Major Equipment: Apparatus to measure thermal conductivity of metal rod, Composite wall apparatus, Pin fin apparatus, critical radius apparatus, transient heat transfer apparatus, Natural and force convection apparatus, Stefan Boltzman apparatus, Emissivity measurement apparatus, Hair pin heat exchanger, Finned heat exchanger, Shell and tube heat exchanger, film and drop wise condensation apparatus

List of Open-Source Software/learning website:

1. https://onlinecourses.nptel.ac.in/noc23_ch65/preview
2. https://onlinecourses.nptel.ac.in/noc26_me53/preview
3. https://onlinecourses.nptel.ac.in/noc26_me86/preview
4. https://onlinecourses.nptel.ac.in/noc26_me94/preview
5. https://onlinecourses.nptel.ac.in/noc26_ch10/preview
6. https://onlinecourses.nptel.ac.in/noc26_me03/preview
7. https://onlinecourses.nptel.ac.in/noc26_me85/preview



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List of Indian standards related to the course: Faculty members are required to give introduction about various Indian standards related to the course during theory and/or practical sessions. Students may be asked to prepare a report on one or more related Indian standards under PBL.

1. IS 3346: 1980 (Reaffirmed 2004): Method for the Determination of Thermal Conductivity of Thermal Insulation Materials (Two Slab Guarded Hot Plate Method).
2. IS 9403: 1980 (Reaffirmed 2004): Method of Test for Thermal Conductance and Transmittance of Built-up Sections by Means of Guarded Hot Box.
3. IS 9490: 2018: Method for Determination of Thermal Conductivity of Thermal Insulation Materials (Water Calorimeter Method).
4. IS 14164: 2008: Industrial Application and Finishing of Thermal Insulation Materials at Temperatures above -80°C and up to 750°C — Code of Practice.
5. IS 3069: 1994: Glossary of Terms, Symbols and Units Relating to Thermal Insulation Materials.
6. IS 4503: 1967 (Reaffirmed 2024): Specification for Shell and Tube Type Heat Exchangers. This covers the design, construction, inspection, and testing of cylindrical shell and plain tube heat exchangers, primarily for the petroleum and chemical industries.

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL category	Name of the activity	No. of hours	Evaluation Criteria
1.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Mini Project	15h	Based on the novelty of project, technical understanding, report quality and presentation
2.	Case Study Analysis / Seminar	Seminar	15h	Based on the quality of report and presentation, technical understanding
3.	Micro project	Micro project	8h	Based on the novelty of project, technical understanding, quality of report and demonstration
4.	Industry/Research laboratory visit	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
5.	Video Based Learning	Technical video-based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
6.	Assignment / Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 4 h each Total = 20h	Based on the correctness of submitted assignment
7.	Group Discussion / Quiz / Simulation	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB, modeling and Analysis software or any	5 small coding-based assignment of 2h each Total = 10h	Based on the coding solution submitted.



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		other software		
8.	Video Based Learning	Self-learning online course	Minimum duration of the course should be 10h	Examination based assessment at the end of course. Based on the certificate produced.
9.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
10.	Video Based Learning	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
11.	Research Paper Review / Analysis	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20h	Summarize research paper and evaluation critical parameters
12.	Poster / Chart / PowerPoint presentation	Poster/chart/power point preparation on technical topics	Duration = 6h	Based on poster/chart preparation and presentation skills
13.	Industry/Research laboratory visit	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/sustainability/any other issue	Duration = 15h for industrial exposure Problem identification and tentative solution = 10h Total = 20h	Based on evaluation of critical problems and solutions
14.	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1h – 3h per topic	Based on performance in group discussion, technical depth, knowledge etc.
15.	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
16.	Group Discussion / Quiz / Simulation	Application/Software development	Duration = 10h	Depending on the complexity of the Application/Software
17.	Assignment / Technical Writing / Research Writing	Research paper publication	Duration = 10h	Based on submission of proof of publication
18.	Micro project	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10h	Based on the performance of the equipment
19.	Industry/Research laboratory visit	Expert lecture/session	Duration 3h For attending the lecture/session– 2h and for report writing 1h	Based on the proof of attendance and report submitted
20.	Video Based	Annotated Video	10h (Preparation +	Based on accuracy of



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	Learning	Explanation of Concept/Problem	Recording + Submission)	explanation, clarity, and presentation style.
21.	Assignment / Technical Writing / Research Writing	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
22.	Assignment / Technical Writing / Research Writing	Preparation of a report on Indian Standard(s)	10h (study of Indian Standard(s) + report	Based on report quality and understanding of the relevant Indian Standard(s).

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Heat Transfer **compulsorily incorporates Mini Project – 10 Marks and Seminar – 10 Marks as PBL activities.**

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
3. All the suggested activity should be related to the subject.
4. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
5. Rubrics for the evaluation will be prepared by the faculty members.
6. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.
